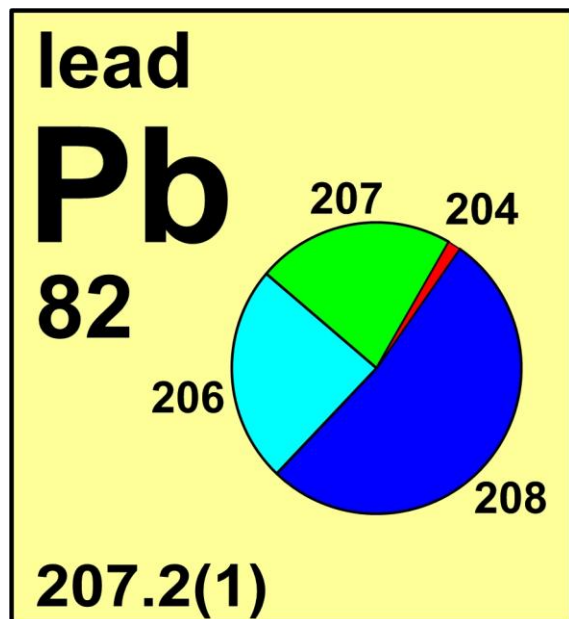


lead



Stable isotope	Atomic mass*	Mole fraction
^{204}Pb	203.973 0436	0.014
^{206}Pb	205.974 4653	0.241
^{207}Pb	206.975 8969	0.221
^{208}Pb	207.976 6521	0.524

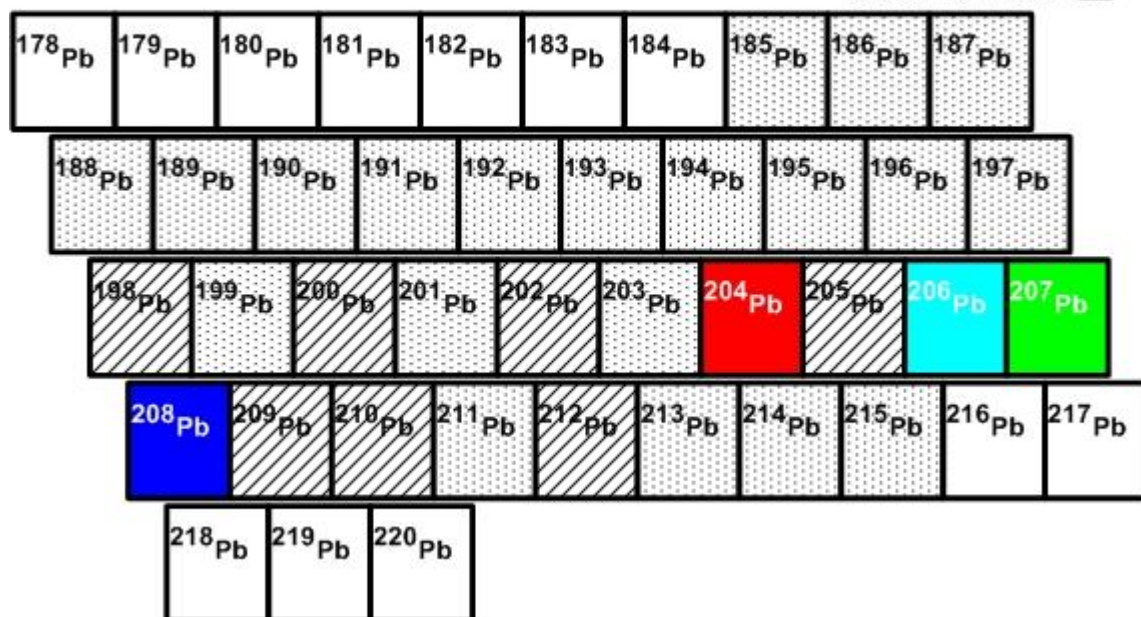
* Atomic mass given in unified atomic mass units, u.

Half-life of radioactive isotope

Less than 1 second

Between 1 second and 1 hour

Greater than 1 hour



Important applications of stable and/or radioactive isotopes

Isotopes in the environment

- 1) Since different regions have different isotopic signatures of lead, it is possible to trace the history and origins of pollutants using the four stable isotopes of Pb (^{208}Pb , ^{207}Pb , ^{206}Pb , ^{204}Pb).

- 2) $^{206}\text{Pb}/^{207}\text{Pb}$ isotope ratios are useful in understanding pollution present day. Being able to trace the source of lead pollution allows for a better understanding of the movement and impact of anthropogenic pollutants.
- 3) Recently, scientists have analyzed lead in air pollution in California and discovered it to be Asian in origin. Chinese airborne particles have higher ^{208}Pb concentrations (as $^{208}\text{Pb}/^{207}\text{Pb}$ vs $^{206}\text{Pb}/^{207}\text{Pb}$), which distinguishes the Pb isotopic signature between Asian and North American airborne particles. The discoveries made in this study could have important implications in the understanding of atmospheric mixing and the way pollution travels.
- 4) Mapping distribution of lead pollution by studying ^{204}Pb , ^{206}Pb , ^{207}Pb and ^{208}Pb also allows for the determination of which human activities contribute most to lead pollution.



Figure 1: Suspended atmospheric dust over California, likely originating in Asia.



Figure 2: A Roman statue. Studies have shown that some of the significant lead pollution originated in the Roman Empire.

Isotopes in hydrology

- 1) The study of lead isotope ratios can model pollution distribution in bodies of water as well as on land.
 - a. For example, in one study of lake Härsvatten in Sweden, an analysis of the $^{206}\text{Pb}/^{207}\text{Pb}$ ratio at different sediment depths at different areas throughout the lake showed patterns of accumulation of lead pollution. In some cases, these patterns can also be related to sediment distribution patterns.
 - b. Another study used ^{210}Pb dating to study vertical accretion in canals and wetland areas in Louisiana over the last 80-100 years₈ and determine its effect on the areas.

Isotopes in forensic science

- 1) Lead is stored in the bones and in teeth. If a person has moved, the teeth can still maintain lead from their place of origin long after the person relocated. Bone, too, can store lead for long periods of time (about 20 years) and so some skeletal lead may be older and different from other skeletal lead and may be reflective of previous exposure. By studying $^{206}\text{Pb}/^{204}\text{Pb}$ ratio and $^{207}\text{Pb}/^{206}\text{Pb}$ ratio it is possible to determine someone's place of origin. Lead was one of the isotopes analyzed in the iceman's teeth and bones to help determine his place of origin.
- 2) The decay of ^{210}Pb in a corpse can help determine how long a person has been dead.



Figure 3: Lead isotopes helped trace the Iceman's geographic origins.

Isotopes in dating/archaeology

- 1) Different geological time periods as well as different regions have different isotopic signatures of lead.
- 2) Three of the stable isotopes of lead (^{206}Pb , ^{207}Pb , ^{208}Pb) derive from the radioactive decay of uranium and thorium and are unaffected by environmental and metallurgical processes. So, by examining the ratios of the different lead isotopes, it is possible to approximate the

age of a material. It is also possible to use this information to trace the origins of an object or material.

Isotopes in health/safety

- 1) Different sources of lead exposure generally have different isotopic signatures. By studying the isotopic ratios of $^{208}\text{Pb}/^{206}\text{Pb}$ versus $^{207}\text{Pb}/^{206}\text{Pb}$ or $^{206}\text{Pb}/^{204}\text{Pb}$ vs. $^{207}\text{Pb}/^{204}\text{Pb}$ the isotopic levels of lead in the blood can be used to help determine which, of a few isotopically distinct potential sources, may have caused the problem.
- 2) Also, by mapping areas heavy in lead pollution, it can be determined which of these areas may present a public health risk.